Preserving Order in Highly Charged Colloidal Sediments: A Potential Route to Self-Assembled Photonic Crystal Templates

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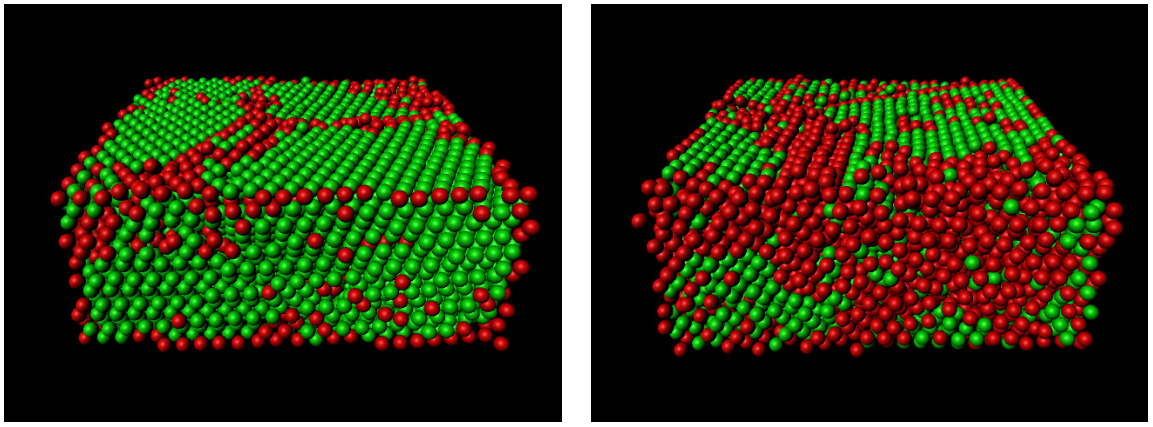
A three-dimensional real-space study is presented on the structural evolution of sedimented colloidal crystals upon gradual increases in ionic strength. Monodisperse SiO_2 spheres, 1 μm in diameter, are sedimented onto a glass coverslip in an index-matched solution of glycerol and water. Because of a negatively charged surface, the SiO_2 colloids have large inter-particle separations and constitute large, highly ordered crystalline domains. Upon the addition of 1 M NaCl, the negatively charged surfaces become screened out and the lattice contracts into adhesive surface-to-surface contacts. In this work, we present time resolved spatial data of colloidal sediments imaged with a laser scanning confocal microscope (LSCM) during NaCl addition. Our results show that the initial long-range crystalline order can be preserved when [NaCl] is slowly increased from 0 to 1 M. This suggests that charge-stabilized colloidal sediments with long-range order can be used to produce thick, large-area photonic crystal templates that are mechanically robust and unaffected by drying.



(a) initial (b) final

Fig. 1: These are 3-dimensional representations of an actual sedimented colloidal crystal. The sample was prepared by allowing 1 μm SiO_2 spheres to sediment onto a glass coverslip in an index matched solution of glycerol and water. The data was obtained using LCSM and the position of each colloid was plotted in perspective. The spheres are drawn to scale and color coded according to their local orientational order to highlight defect regions: green for perfect in plane hexagonal order, red for less than perfect order. Part (a) shows the colloidal crystal before NaCl was added. Part (b) shows the colloidal crystal 5 hours after 1M NaCl was added.